

GLOBAL WARMING:
POLICIES FOR AMELIORATION

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SCIENCE AND TECHNOLOGY DIVISION

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TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
BACKGROUND	2
GREENHOUSE GASES	3
REDUCTION TARGETS	5
FOSSIL FUELS AND CO ₂ PRODUCTION	8
ENERGY EFFICIENCY AND CONSERVATION	10
KEY CANADIAN ENERGY SECTORS	15
A. Transportation and CO ₂	15
B. Electricity Generation and CO ₂	19
C. Efficiency Enhancements	21
1. Industrial Energy	21
2. Residential and Commercial Buildings	21
ENERGY ALTERNATIVES	22
A. Non-Renewable Sources (Nuclear)	23
B. Renewable Sources	24
LAND USE MANAGEMENT	27
A. Deforestation	27
B. Agricultural Practices	31
OTHER GREENHOUSE GASES	32
INTERNATIONAL POLICIES	34
GOVERNMENT PROCESSES	36
DISCUSSION	38
SELECTED REFERENCES	41





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INTRODUCTION

The scientific community generally agrees that, due to the large quantities of atmospheric pollutants generated since the beginning of the industrial revolution, global warming is increasing at the fastest rate in recorded history. Although the predictions of the amount of warming that may take place in a given period of time in a given locality might vary depending on the model used, their general outlook is the same... "Humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war. The Earth's atmosphere is being changed at an unprecedented rate by pollutants resulting from human activities, inefficient and wasteful fossil fuel use and the effects of rapid population growth in many regions. These changes represent a major threat to international security and are already having harmful consequences over many parts of the globe."(1)

It seems that once again, not having heeded the warnings of the enlightened, we are faced with all the more urgent need for changes in policies. There is general agreement, however, that if the political will is strong enough, we can still slow down the rate of increase in global warming. Time is of the essence; in the words of those who participated at the Toronto Changing Atmosphere Conference, "It is imperative that we act now." Policy decisions will have to be made in the face of uncertainties

(1) Conference Statement, The Changing Atmosphere: Implications for Global Security, World Meteorological Organization, Toronto, 27-30 June 1988, 12 p.

at many levels: uncertainties about the basic sciences underlying global warming, uncertainties about the effects of reducing the level of emission of greenhouse gases on global warming, and usual political uncertainties that often govern the decisions made by the policymakers. For it is the policy decisions made at local, regional, national and international levels by both public and private institutions that will affect the future rate of greenhouse gas buildup.

Though there is also a need for policies and strategies for adapting to global warming, this paper will discuss only policies which aim to ameliorate what is sometimes known as the "greenhouse effect."

BACKGROUND

Several studies in recent years have indicated that policy measures could play a role in reducing the possible total warming over the next century. Some of these studies have examined what might be the result of implementing policies both in a world where the rate of economic growth remained relatively stable, and in a more complex scenario where the growth rate increased rapidly. Also examined were the effects of implementing policies at different levels of strictness.

One of the most recent such analyses was conducted by the United States Environmental Protection Agency, and resulted in a draft report of approximately 1,000 pages.⁽²⁾ This report, which was prepared at the request of Congress, was entitled Policy Options for Stabilizing Global Climate (hereafter referred to as the EPA Report). The study was modelled strictly on the basis of effects possible from implementing the policies without incorporating economic or social costs in the analysis. Although this may be considered simplistic, since policymakers often do choose one policy over another based, at least in part, on those

(2) United States Environmental Protection Agency, Office of Policy, Planning and Evaluation, Policy Options for Stabilizing Global Climate, Draft Report to Congress, Executive Summary, February 1989.

parameters, the analysis is successful in indicating what is theoretically possible.

GREENHOUSE GASES

According to the EPA Report, "No single activity is the dominant source of greenhouse gases; therefore, no single measure can stabilize global climate. Many individual components, each having a modest impact on greenhouse gas emissions, can have a dramatic impact on the rate of climatic change when combined." There are some generalizations that can be made, however, and since it is possible to see clearly which gases are the major contributors, policy changes might help to reduce the effects of these gases.

Figure 1 indicates that carbon dioxide (CO₂) is the largest contributor to the greenhouse effect, followed by methane (CH₄), chlorofluorocarbons (CFCs), and nitrous oxide (N₂O). It is important to note that gases other than carbon dioxide have been playing a larger and larger role in global warming since we entered the chemical era after the Second World War. Carbon dioxide is a fundamental product of burning fossil fuels (coal, oil and gas; listed in descending order of their relative CO₂ impact per unit of energy produced), and is also the result of deforestation. The largest methane source is the decay of organic matter in the absence of oxygen (usually underwater), while CFCs are produced only by humankind. Aside from those indirectly generated from automobile emissions, the sources of nitrous oxides are not well understood but are likely related to soil processes.(3)

(3) For a more detailed account of the greenhouse effect and the contribution of the different gases, see Robert Milko, The Greenhouse Effect and Climatic Change, CIR 79-2E, Library of Parliament, Ottawa.

Figure 1
Greenhouse Gas Contributions to Global Warming

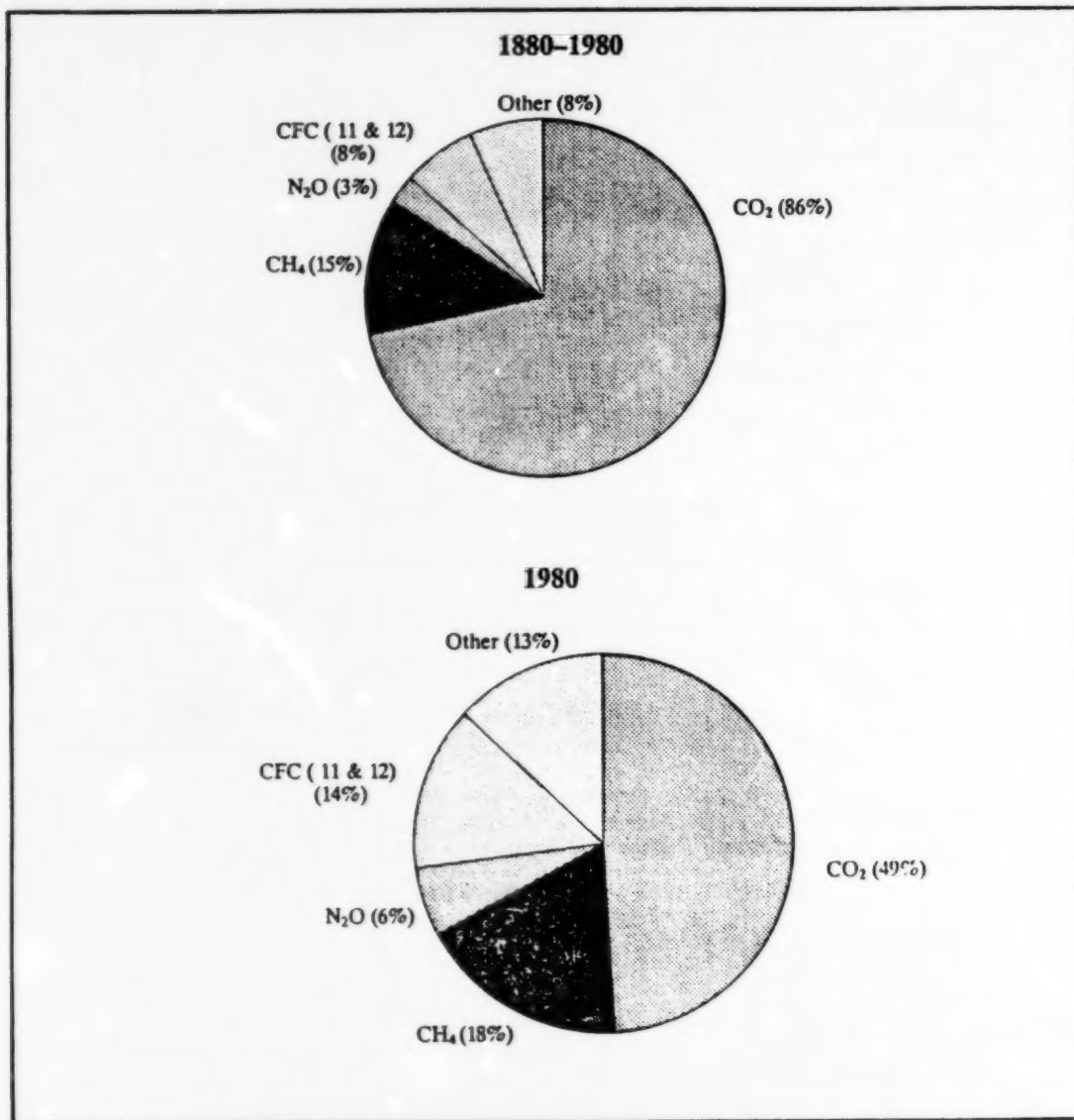


Figure 1. Based on estimates of the increase in the concentration of each gas during the specified period. Other includes additional CFCs, halons, changes in ozone, and changes in stratospheric water vapour. The other category is quite uncertain.

Source: EPA Executive Summary, p. 12.

REDUCTION TARGETS

Because greenhouse gases remain in the atmosphere for decades to centuries and are being emitted faster than they are being removed, stabilizing emissions would not stabilize concentrations. According to EPA, even if emissions remained stable at 1985 levels, the greenhouse effect of these gases would continue to increase for the next century. Table 1 indicates the approximate reductions in anthropogenic emissions required to stabilize atmospheric concentrations of each compound at current levels.

It is just as important to understand the contributions of different activities to global warming in order to determine where we might best direct strategies. Figure 2 indicates that energy use and production contribute 57% of global warming, for the most part through producing CO₂ by burning fossil fuels. Since CFCs, which contribute 17% and could be controlled because there is already strong international cooperation (see concerns about non-signatory countries in the section on International Policies), it seems clear that the best opportunity for control of greenhouse gases lies in adjustments to our energy production.

In fact, the Toronto Conference recommended as an initial goal that we should reduce CO₂ emissions globally by approximately 20% of 1988 levels by the year 2005. Implicit in this recommendation was that this was to be achieved through modification of energy policies, and on the understanding that a 50% reduction from present emission levels is required to stabilize CO₂ levels. Most discussions of policy changes to slow down the rate of global warming use this initial target of a 20% reduction for CO₂. Discussions on CFCs generally suggest that the ultimate target should be a 100% reduction in further production of fully halogenated CFCs by the year 2000. This should be accomplished by revising the Montreal Protocol in 1990 (the reduction target in the Protocol is at present set at 50% for the year 1999). There may be some concern that, although the fully halogenated CFCs will be phased out, their replacements will continue to have the same greenhouse gas capability. A molecule-by-molecule comparison of their greenhouse gas potential should be carried out, as has been done

Table 1

Approximate Reductions in Anthropogenic Emissions
Required to Stabilize Atmospheric Concentrations at Current Levels

<u>Gas</u>	<u>Reduction Required</u>
Carbon Dioxide (CO ₂)	50-80%
Methane (CH ₄)	10-20%
Nitrous Oxide (N ₂ O)	80-85%
Chlorofluorocarbons (CFCs)	75-100%
CO, NO ₂	Freeze

Source: EPA Executive Summary, p. 15.

Figure 2
Activities Contributing to Global Warming

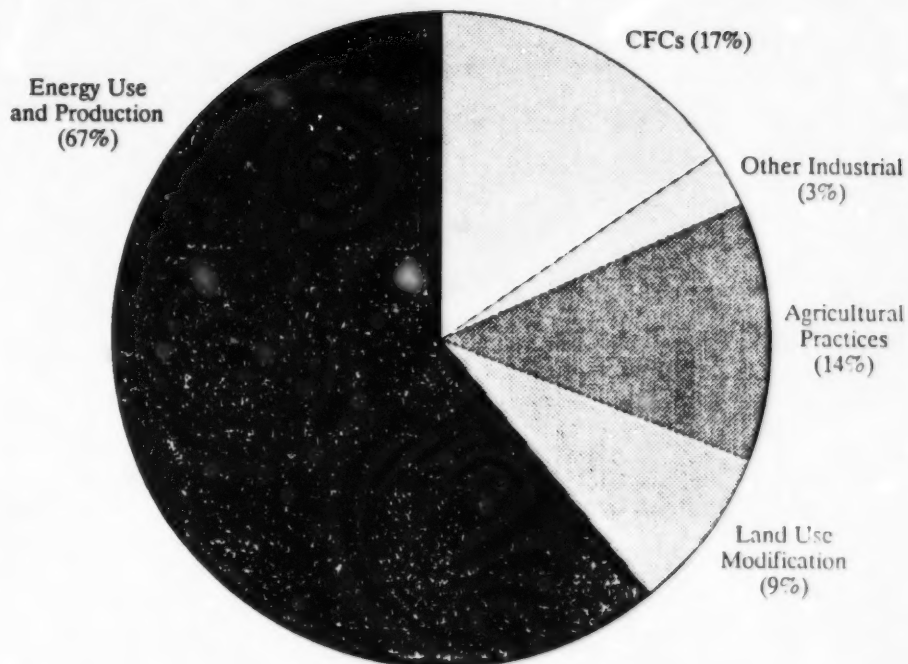


Figure 2. Estimated contribution to greenhouse warming for the 1980s, based upon each activity's share of greenhouse gas emissions, weighted by the greenhouse gas contributions to global warming shown in Figure 3.

Source: EPA Executive Summary, p. 55.

to assess their ozone-depleting potential. Targets for the other greenhouse gases have received only limited formal discussion.

FOSSIL FUELS AND CO₂ PRODUCTION

CO₂ emissions have been relatively stable during the last decade, but atmospheric concentrations have continued to increase because these emissions are still greater than their uptake by the oceans and other sinks. A further complication is that the developed nations, who have undoubtedly contributed the most to the CO₂ buildup in the past, are now contributing proportionally less. For example, in 1950, countries belonging to the Organisation for Economic Co-operation and Development (OECD) consumed about 75% of all commercial energy supplies, the centrally-planned economies of Europe and Asia consumed 19%, and developing countries consumed 6%. By 1985, the percentages had shifted to 50%, 32% and 15%, respectively.⁽⁴⁾ This indicates the growing need for true global cooperation, since developed countries may not only have to alter their own national energy policies but also adjust their bilateral and multilateral assistance programs. This was also suggested by the Toronto Conference on the Changing Atmosphere.

The three different major fossil fuels produce different amounts of carbon dioxide per unit of energy: oil releases approximately 70% as much CO₂ per unit of energy as coal, burning natural gas emits only 50% as much, while burning synthetic fuels derived from coal produces much more CO₂ than does burning coal directly.^(5,6) There do not appear to be good data available for the CO₂ emissions when synthetic fuels from

(4) EPA Report (1989).

(5) I. Mintzer, "Our Changing Atmosphere: Energy Policies, Air Pollution and Global Warming," Conference Proceedings, The Changing Atmosphere: Implications for Global Security, World Meteorological Organization, Toronto, 27-30 June 1988, 123 p.

(6) EPA Report (1989).

Canadian tar sands are burnt, but according to the Canadian Climate Centre, they produce 120% more CO₂ than does burning coal.⁽⁷⁾ The above EPA reference also provides the relative CO₂ emissions from producing when the production side is calculated. The emissions for synthetic fuels are extremely high, but no data are provided for the production side of the conventional fossil fuels. This aspect is of the utmost importance in understanding the real costs of fossil fuels in CO₂ currency. These figures for fossil fuels derived from Canadian tar sands are needed for making appropriate choices in energy policies.

Adjusting the mix of energy supplies away from the carbon-intensive fuels is one approach that cannot be ignored. In particular, use of natural gas could be encouraged by reference to its availability and to its use as a transitional fuel in the move to a non-fossil fuel world. In a general sense, policies that influence choices can be applied to all initiatives attempting to reduce the greenhouse effect.

There are two possible approaches to reducing CO₂ production from fossil fuels: i) adjusting the fossil fuel mix, as mentioned above; or ii) reducing the overall energy consumption. A combination of the two approaches would be appropriate, and according to the EPA study and many others,^(8,9,10,11,12) the use of technologies and practices that use less

(7) Personal communication, Henry Hengeveld.

(8) Natural Resources Defense Council, Cooling the Greenhouse: Vital First Steps to Combat Global Warming, May 1989, 72 p.

(9) Passmore Associates International, Electrical Efficiency Opportunities for Ontario, July 1989, 33 p.

(10) J.B. Robinson, "Decarbonating Energy Policies: Policy and Implementation Issues Associated with Reducing CO₂ Emissions Through Increased Energy Efficiency," Paper prepared for A Little Breathing Space: Carbon Dioxide Emission Reduction Strategies, Budapest, Hungary, 14-15 April 1989, 35 p.

(11) The DPA Group, Study on the Reduction of Energy-Related Greenhouse Gas Emissions, Executive Summary, March 1989, 22 p.

(12) Torrie, Smith and Associates and Marbek Resource Consultants Ltd., Electricity Conservation and Acid Rain in Ontario, March 1989, 50 p.

energy to accomplish a given task (i.e., increased efficiency) will have the largest impact on global warming in the near term.

It should be recognized, however, that fossil fuels will continue to be exploited for decades to come. There is, therefore, a pressing need for improved fossil fuel combustion technologies. This should include a hard look at the potential of economically extracting carbon dioxide in the pre- or post-combustion process.

ENERGY EFFICIENCY AND CONSERVATION

Several recent analyses have indicated that energy-efficient practices could reduce the demand for energy and CO₂ output by 20% (see above references). These conclusions have usually been reached by examining the main energy sectors and their individual capacities for increased efficiency. It might first be appropriate to define efficiency more carefully and place it in an economic context.

An increase in energy efficiency can simply be described as using less energy to perform a given task. In simple terms, an increase in efficiency often occurs concomitantly with a decrease in energy intensity, that is, for example, a reduction in the amount of energy required to produce a unit of Gross Domestic Product (GDP). Requiring less energy to produce a unit of GDP, i.e., lower energy intensity, is of course a desirable goal. Therefore, a change in intensity is generally viewed as a rough index of a change in the energy efficiency of an economy; a decrease in a country's energy intensity implies (though does not guarantee) an increase in energy efficiency. This concept can also be applied to a province, an industrial sector, or a particular industry.

In making decisions that would promote efficiency, it is useful to consider how energy intensity could be lowered by: i) actual changes in the efficiency of providing energy services (e.g., changes in the distribution system to eliminate waste in power transmission); ii) changes in the level of energy-using activities (e.g., changes in the demand for services or consumer goods, because of changed attitudes through

public education or economic incentives); and iii) what might be considered structural changes (other changes including changes in output and input mixes). This last comes from the realization that the extraction side of energy sources (e.g., fossil fuels and uranium) is requiring more energy per unit of energy that is ultimately produced. This is because of the growing difficulty in finding and exploiting smaller or lower-grade non-renewable energy deposits in more remote locations.

As an example, according to a report of the International Energy Agency (IEA), when examining the OECD as a whole, energy intensity dropped by 21% from 1973 to 1982. In 1985, this decrease allowed for a "saving" of a quantity of CO₂ amounting to 12% of global emissions in that year. There is also evidence that efficiency improvements have been predominantly responsible for reducing sectoral energy intensities in some countries, and improved efficiency of energy-using equipment processes and buildings seems to have been the most significant contributor to this.(13)

There are those who contend, however, that we know more about the economic and technological potential for increased efficiency than about how and why such improvements will or will not be put into practice. They believe that reliance on market mechanisms alone would not produce economical levels of energy efficiency, and that more understanding of the behavioural and attitudinal aspects of the market is required. An examination of the successes and failures of specific programs for energy efficiency(14) indicates that there is some merit in this argument. As well, price-based approaches to energy efficiency raise the problem of the unequal impact of increased energy prices on individuals; those in lower income brackets might have to pay a higher proportion of their income to meet their energy requirements.

It should be noted, however, that data supporting the importance of using behavioural responses in implementing energy efficiency

(13) Robinson (1989).

(14) Ibid.

programs is only evident in the context of the individual, who does not always make economically-based decisions. Most important, one-sixth of the energy use is in the commercial sector and two-fifths in the industrial sector, where decisions appear to be based on more practical reasons, e.g., economic incentives. This is not to imply that the power of public pressure and public relations should be overlooked.

A least-cost planning approach to energy policy planning (also known as "demand management") implies treating increased energy efficiency as a supply source. Least-cost planning has been extremely successful in some regions such as the Pacific Northwest of the United States. In the context of the above discussion on how energy intensity might be lowered, it actually embodies concepts i) and iii) (p. 10-11), and if policies included programs that would encourage consumers to become more energy efficiency conscious, it would then integrate the second concept as well.

Table 2 indicates one interpretation of the potential for increased energy efficiency in industrialized market economies. It outlines a set of end-uses, efficiency measures, and technologies which represent priority areas where large technical and economic gain could be made. The listing is by no means complete.

Since we are concerned with CO₂ emissions when addressing energy in the context of global warming, it is important to interpret the information regarding potential for efficiency (as in Table 2) in view of various end-uses. There are many different ways that end-uses could be categorized, the more detailed the better for targeting specific policies; however, the exercise can be made readily comprehensible by lumping similar end-uses together. Table 3 shows two such groupings, one used by Robinson and IEA,⁽¹⁵⁾ and another used by Jessup.⁽¹⁶⁾ The major difference

(15) Ibid.

(16) P. Jessup, Carbon Emissions Reduction Options in Canadian Transportation, Discussion Paper produced for Friends of the Earth, 1 June 1989, 7 p.

Table 2

Some Key Areas of Potential for Increased
Energy Efficiency in Industrialized Market Economies

Sector	End-Use	Measures	Sample Technologies	Efficiency Potential*
Residential	Space Heating & Cooling	-building shell improvements -heating system efficiency improvements	-insulation -sealing -superwindows	50%
	Appliances	-more efficient appliances	-insulation -bulbs -motors	50%
Commercial	Space Conditioning	-building shell improvements -better controls	-insulation -sealing -integrated control systems	50%**
	Lighting	-improved lighting systems	-bulbs -ballasts	30%**
Industrial	All	-process change*** -product change***	?	***
	Process Heat	-heat recovery -improved heating systems	-insulation -cascading -advanced heating systems	30-50%**
	Mechanical Drive	-improved motors	-cogeneration -variable speed drives -linkage systems -more efficient motors	30-50%**
Transportation	All	-vehicle efficiency	-weight and size reductions -improved aerodynamics -improved engine efficiency -reduced rolling resistance -variable speed transmissions	50%

* Rough estimates, averaging across new and existing buildings, processes and activities. Sources: Goldemberg *et al.* (1988); IEA (1987); Robinson (1987).

** Average of subsectoral efficiencies and ranges used in Table 5.

*** Not undertaken for energy efficiency reasons, or included in Table 5.

Source: Robinson (1989), Table 3.

Table 3

Sectoral Contribution to CO₂ Emissions
in OECD Countries and in Canada

<u>Sector</u>	<u>% Contribution to CO₂ Emissions in OECD Countries¹</u>	<u>% Contribution to CO₂ Emissions in Canada²</u>
Residential	20%	13%
Commercial	15%	8%
Industrial	36%	28%
Transportation	27%	30%
Electricity Generation	N.A. ³	21%

¹ Source: Robinson (1989).

² Jessup (June 1989).

³ Not applicable in this analysis.

is that Robinson has factored electricity generation into the other sectors whereas Jessup, whose data are actually from Environment Canada, identifies electricity generation separately. Either approach is reasonable, with preference depending on the goal of the exercise.

Using the sectors identified by Robinson in Table 3, and weighing Table 2 according to these CO₂ contributions on a proportional basis, produces Table 4, which represents a very rough preliminary attempt to set priorities for energy efficiency policies based upon both their overall potential and also their contribution to CO₂ reduction.

KEY CANADIAN ENERGY SECTORS

A. Transportation and CO₂

According to Table 4, originally compiled by Environment Canada, the transportation sector accounted for 30% of the carbon emissions in 1985, of which approximately 80% was generated by personal and commercial light-duty vehicles. It is not expected that this would have changed to any substantial degree by 1989. Aside from the direct CO₂ emission problem and the multitude of other environmental problems associated with the burning of fossil fuels by transport vehicles (e.g., toxic and oxidant air pollution associated with internal combustion engines in transport vehicles - hereafter referred to as automobiles), automobile emissions have a secondary effect in relation to the greenhouse effect. When running inefficiently, they produce greater quantities of carbon monoxide (CO). CO removes hydroxyl radicals in the atmosphere, which normally scavenges methane, another greenhouse gas. A requirement for annual checks of automobile emission would help to reduce this problem.

It is quite feasible that technological improvements could be made in the efficiency of the engines used in automobiles in the next decade. In fact, there have been significant improvements in the last 15 years as a result of consumer reaction to rising gasoline prices and manufacturer response to changing consumer preferences and voluntary federal fuel efficiency standards. The technological potential, coupled

Table 4
Energy Efficiency and CO₂ Reduction
in OECD Countries

<u>Sector</u>	<u>End-Use</u>	<u>Measure</u>	<u>Efficiency Potential (%)</u>	<u>Contribution to CO₂ Emissions (%)</u>	<u>Weight</u>
Residential	Space Heating & Cooling	-building shell improvements -heating system efficiency improvements	50%	20%	10.0
	Appliances	-more efficient appliances -building shell improvements			
Commercial	Space Conditioning	-better controls	40%	15%	6.0
	Lighting	-improved lighting systems			
Industrial	Process Heat	-heat recovery -improved heating systems	40%	36%	14.4
	Mechanical Drive	-improved motors			
Transporta- tion	All	-vehicle efficiency	50%	27%	13.5

Sources: Tables 3 and 4.

Notes

1. In the absence of data on energy use and efficiency potential by end-use, only sectoral totals are shown.
2. Weight = Efficiency Potential X Sectoral Contribution to CO₂ Emissions X 100.
3. Excludes energy supply sector.

Source: Robinson (1989), Table 5.

with the rapid turnover of vehicle fleets (due to their limited lifespan), indicates that substantial CO₂ reductions might be possible over the next decade or two.

Canada does not have any statutory fuel economy standards, but does have voluntary Corporate Average Fleet Economy (CAFE) standards, which the government asked manufacturers to meet during the 1980s. The current fuel efficiency rating for new cars and light-duty trucks is 27.5 miles per gallon. There is no doubt that fuel efficiencies can be substantially increased as there are already many commercially available vehicles with fuel economy ratings greater than 45 miles per gallon, and prototypes that can achieve levels of more than 80 miles per gallon. Those that are commercially available at present employ technologies that pay for themselves over the lifetime of the vehicle, even at the present low cost of fuels.

The 1989 modelling and projection exercise by Jessup⁽¹⁷⁾ has indicated that if the present CAFE standard of 27.5 miles per gallon is retained, by the year 2005 gasoline consumption will have increased by 23% over 1988 consumption. Increasing the average fleet fuel economy by 5.8%, however (the rate of improvement Canada's voluntary CAFE standards called for in the early 1980s), would represent a 49% reduction from gasoline consumption projected for 2005. In the increased efficiency scenario, compact cars and standard cars would respectively have fuel efficiency ratings of 64 and 47 miles per gallon by the year 2005.

In view of these capabilities, several approaches have been suggested. Statutory standards could be implemented to increase fuel economies incrementally, while economic incentives could include supplemental "gas-guzzler taxes" on inefficient cars (as is done in the U.S.A.) and "gas-sipper rebates" for efficient vehicles. Pressure could also be exerted by a "carbon tax," that is by incrementally increasing the cost of gasoline; the price of gasoline and diesel fuel has been shown to influence the choices and behaviour of consumers. This could have an

(17) Ibid.

effect on the manufacturers, who would be attempting to meet the market demand for more fuel-efficient vehicles. Funds raised from a "carbon tax" could be placed in a trust fund to reduce impacts on low-income households, fund mass transit, expand energy conservation programs, assist reforestation, and help in further development in alternative energy technologies such as biomass fuels (ethanol production for use as a fuel additive).

Adjusting the mix of fuels for vehicles could also help reduce both the greenhouse effect and other atmospheric pollutants. One possibility is use of natural gas, whose greenhouse potential is lower than that of regular gasoline. This point, in conjunction with the fact that Canada is rich in natural gas reserves, makes gas fairly attractive as a transitional fuel. Its abundance and cost were recognized in a former federal government program that subsidized the conversion of regular fuelled vehicles to natural gas or propane.

Ethanol can be used effectively at a 10% mix with gasoline and, since it is produced from vegetative fermentation (biomass fuel), it makes essentially no net contribution to the greenhouse effect. CO₂ produced when ethanol was burned would be reabsorbed to grow more vegetation that would be used for further ethanol production. In particular, ethanol has been shown to enhance octane levels of gasoline without the emission of toxic pollutants produced by other octane enhancers. Although biomass fuels do produce their own emissions, in appropriate combustion applications they would provide a relative environmental gain.

The technology for ethanol production from biomass has increased production efficiency by approximately 200 times in the last 10 years, and there are good indications that its production, now costing 42 cents per litre, will go down to 29 cents per litre in five years.⁽¹⁸⁾ Support for this development might be desirable in view of the fact that the petroleum industry resists supporting its production and incorporation into the standard fuel mix. It is interesting to note that more initiatives in the United States encourage this technology than in Canada;

(18) Personal communication, Patrick Foody, Techtrol Ltd.

for example, there is the bill to amend the Clean Air Act and a California requirement to have 300,000 vehicles with flexible fuel engines on the market by 1992. It is estimated that producing a car with this flexibility would cost between \$250 to \$300 more than producing a regular car.

B. Electricity Generation and CO₂

In Canada, 21.5% of our carbon emission is from the generation of electricity. There are many indications that more careful planning, in conjunction with a greater reliance on cost-effective renewable sources, could reduce the demand for electrical energy, and hence for electricity generated by fossil fuels. One suggested strategy is least-cost planning or demand-side management.

The Pacific Northwest of the United States and California have been cited as good examples of places where least-cost planning has been effective, at least in the last 10 years. The first official plan adopted was in the Pacific Northwest, and included legislation specific to the implementation of the program (Northwest Power Act). The plan initially deferred all new large-scale generators in an area which had earlier been the site of one of the world's most ambitious nuclear power plant construction programs. Essentially, the concept allows for meeting power demands through the most economical means. This might mean, for instance, introducing efficiency improvements that would lower the demand and allow present production to be more effective, rather than paying to have more power produced.

For example, if a utility proposes a coal-fired power plant, the planning process asks whether efficiency improvements in residences, commercial buildings and industries could meet the same energy needs at lower cost. Costs are evaluated over the anticipated life cycles of the competing conservation and power plant options, allowing efficiency and energy supply to compete on a level playing field. Such a planning method should also explicitly require that additional costs be imputed to options involving fossil fuel combustion so that environmental costs of global

warming would be taken into account. This is a subset of the concept of environmental accounting by means of satellite accounts,(19) a method of factoring resource depletion and environmental degradation into the costs of a project or product.

Analyses conducted in Ontario indicate that using such a method would save energy in the province. Torrie et al.(20) used Ontario Hydro's 1987 frozen efficiency forecast as a baseline for the year 2000's electricity demand; when conservation and efficiency potential was measured against this, there was a savings potential equivalent to 25% of current annual production and 18% of the frozen efficiency forecast for 2000. Nearly half the identified savings potential is in the commercial and institutional buildings sector (lighting systems, pumps, fans and motors), and about one-third is in the residential sector (appliances, electric heat for homes, and electric water heat).

It is interesting to note that this study was conducted, among other reasons, to analyze the effectiveness and the comparative costs of electricity conservation as a means of reducing acid gas emissions in Ontario in the 1990s. The analysis found that scrubbers appear to be an economic option only when the "narrow question of acid gas reduction is considered outside the broader context of power system planning and operation. In this broader context, where the objective is to both meet the demand for electricity and stay within the acid gas emission limits, conservation and efficiency produce a stream of economic benefits that more than offset the higher initial investment (as compared to scrubbers)." This comprehensive study provides a detailed breakdown of where and how such savings could be found in each of the major energy-using sectors.

(19) J.R. Potvin, Rawson Academy of Aquatic Science, Economic-Environmental Accounts: A Conspectus on Current Developments, March 1989, 40 p.

(20) Torrie et al. (1989).

C. Efficiency Enhancements

1. Industrial Energy

Industry accounts for approximately 28% of CO₂ emission in Canada, excluding that from generating electricity for this sector. Advanced industrial processes are available that can substantially reduce the energy required to produce basic materials, particularly when combined with recycling. For example, new technology developed in Sweden uses about half as much energy per unit of steel production as the current U.S. average. Electric motors are estimated to account for about 70% of U.S. industrial electricity use. Case studies show that energy consumption by electric motors could be reduced by 15% from current averages.

Perhaps the biggest hurdles in improving efficiencies in industry are the changes that would be required in the present infrastructure. It has frequently been shown, however, that efficiency increases can offset the cost of such changes in the long term. Energy intensity could be reduced in three general ways: upgrading technology (e.g., technology to capture and use waste heat); using existing equipment more efficiently (operating computer systems so as to minimize energy consumption, by, for example, turning them off when not in use); and reducing the material-intensity of production (building lighter equipment when structurally possible and recycling). The U.S. Department of Energy produced a 1990-1994 Multi-Year Conservation Plan that identified 29 ways for industry to recover waste heat, and 51 ways to make its processes more efficient. NRDC maintains that if fully implemented, these measures would cut the energy use of existing industries by nearly 50%. Cogeneration, which uses the waste heat from heating sources could boost the efficiency of gas heating from 30% or 40% to 75%.

2. Residential and Commercial Buildings

Approximately 21% of Canadian carbon emissions is generated in the residential and commercial sector (predominantly from buildings), of which just over half is the residential component. According to the EPA, improved building shells, lighting, heating and cooling equipment, and appliances are commercially available. In the U.S.A., the most efficient

houses currently being built use only 30% as much heating per unit floor area as the average existing house. There are advanced prototypes and designs for houses using only 10% of current average energy requirements, but indoor air quality must be considered as efficiency methods are implemented.

About 20% of U.S. electricity is consumed for lighting, mainly in commercial and residential buildings. A combination of currently available technology and careful design such as the use of fluorescent light bulbs has been shown to reduce energy requirements for lighting cost-effectively by more than 75%.

There appears to be a fair amount of room for improvement in the efficiency of major appliances. According to the NRDC, U.S. Federal Regulations which were signed into law in 1987, should eliminate the need to build 60 large coal-fired power plants over the next few decades. In Canada, we have only non-compulsory guidelines for labelling the efficiency ratings of major appliances; the possibility of federal standards, similar to those in the United States, should be investigated.

Although there appear to be many ways to improve energy efficiency, there are difficult choices to be made: where to begin and by what approach, when to implement standards, when to tax, when to penalize or when to use economic incentives, how to use a combination of the various approaches. In Canada, we also have to overcome many jurisdictional barriers; this requires a great deal of cooperation between, for example, the federal government and the provinces. Such hurdles, as always, will require a great deal of effort if a national goal is to be realized.

ENERGY ALTERNATIVES

Energy alternatives encompass both renewable and non-renewable energy sources that do not produce CO₂. The concept of altering the mix of fossil fuels to include those that release lower amounts of CO₂ per unit of energy has already been addressed as a transitional policy on the way to using non-CO₂-emitting energy sources, or to reduce

substantially the amount of CO₂ produced per unit of energy. The latter, combined with the application of strong policies requiring increased energy efficiency, could reduce the CO₂ output at the outset.

A. Non-Renewable Sources (Nuclear)

The only viable non-renewable, non-CO₂-emitting energy source of substance is nuclear fission. Globally, nuclear fission provides about 5% of the world's energy, and, until the Chernobyl accident, was increasing in standing as a potential major energy source. Even now, the number of nuclear power plants on which construction had begun prior to Chernobyl will increase their role in the energy shuffle. It is difficult to ignore nuclear fission as a potential major energy source in the long term, and in fact the Toronto Conference stated that the desired reduction of CO₂ would require "revisiting the nuclear power option, which lost credibility because of problems related to nuclear safety, radioactive wastes, and nuclear weapons proliferation. If these problems can be solved, through improved engineering designs and institutional arrangements, nuclear power could have a role to play in lowering CO₂ emissions." It should be noted that this proviso would have to be met for nuclear fission to be publicly accepted, and that the nuclear option is low down in the listing of approaches detailed by the Conference Statement.

It is not unexpected that most of those concerned about the greenhouse effect, in particular the Environmental Non-Government Organizations (ENGOS), are not in favour of pursuing the nuclear option, particularly in the short term. There is some concern that, in the haste to reduce CO₂ emissions, status quo decisions will be made by those in control of the energy sector. Rather, decisions should be made carefully after a good deal of analysis of the potential for gains in conservation and efficiency and in light of economic considerations. One such analysis comparing the nuclear and energy efficiency strategies found the following:

We analyse two popular strategies for reducing fossil-fuel carbon dioxide (CO₂) emissions: revitalizing nuclear power, and improving energy efficiency. Under highly favourable assumptions for nuclear power in

scenarios of moderate to high energy growth, we find that even if large nuclear plants (1,000 MW) could be built every one to three days from now until 2025 (which is impossible in the Third World), global CO₂ emissions would still continue to grow. Thus, nuclear power cannot contribute significantly to abating greenhouse warming, except possibly in scenarios of low energy growth for which the problem is already largely ameliorated by efficiency improvement. In the U.S.A. - the world's largest producer of CO₂ - each dollar invested in electric efficiency displaces nearly seven times as much CO₂ as a dollar invested in nuclear power. Even if the most optimistic aspirations for the future economics of nuclear power were realized today, efficiency would still displace between 2.5 and 10 times more CO₂ per unit investment. We conclude that revitalizing nuclear power would be a relatively expensive and ineffective response to greenhouse warming, and that the key to reducing future CO₂ emissions is to improve the energy efficiency of the global economy.(21)

In spite of these concerns, nuclear fission has been chosen as the primary energy source by some countries for achieving energy security. France and the USSR are good examples. Such countries, in particular France, 70% of whose electricity supply is generated by nuclear reactors, has an exceptionally low rate of carbon emission from its national electrical supply system. In contrast, Sweden may experience an increase in CO₂ emissions as it shuts down and decommissions its nuclear power stations, which have supplied 50% of their electricity generation. It will be interesting to see whether Sweden is able to implement greater efficiency and alternatives based on non-fossil fuels to counter the anticipated increase in emissions.

B. Renewable Sources

The EPA Report states that research on non-fossil energy technologies is a critical need. Yet in Canada, the research that was being conducted by the federal government has come to a halt. According to

(21) B. Keepin and G. Kats, "Greenhouse Warming: Comparative Analysis of Nuclear and Efficiency Abatement Strategies," Energy Policy, Vol. 16, No. 6, December 1988, p. 538-561.

a paper prepared for Friends of the Earth (FOE),(22) "cuts to energy conservation and renewable energy programmes are destroying Canada's ability to put out the fire of the greenhouse effect." In a detailed account, this paper illustrates how "budget cuts made by the government in Energy, Mines and Resources and other parts of the federal system have resulted in a 81% drop in funding for energy conservation and renewable energy development since 1984." Further cuts in related EMR sectors since the FOE paper have accentuated the lack of federal initiatives in these energy fields. Funds have essentially dropped from \$500 million to \$30 million annually. FOE and many others who are aware of the greenhouse effect and policies that contribute to the problem are further frustrated by the federal government's continued support and subsidization of fossil fuel megaprojects.

Hydroelectric power (HEP) is already contributing the equivalent of about 7% of global primary energy production, with the potential for further expansion. In Canada, one of the largest areas for potential expansion is in Quebec, but these large-scale projects have large-scale socio-economic and environmental impacts. Smaller, privately or communally operated HEP may still have some potential here.

Biomass energy, in large part the simple burning of wood, accounts for approximately 10% of global energy consumption but is rarely included in accounts of commercial energy use. Current and emerging technologies could vastly improve the efficiency of biomass use. In the near term, there is substantial potential for obtaining more useful energy from municipal and agricultural wastes. More advanced technologies for producing, collecting and converting biomass to gaseous and liquid fuels and electricity could become economically competitive within a decade. The prospects for integrating biomass gasification with advanced combustion turbines is particularly promising. Environmental and societal impacts related to large-scale biomass use would have to be addressed and include competition with food production, ecological impacts, and emissions of

(22) Kai Millyard, Demolishing the Firehall, Friends of the Earth, 7 November 1988, 13 p.

volatile organic compounds. Biomass conversion into gases such as ethanol has been discussed in the section on Transportation and CO₂.

There is a large range of solar options, either through direct or passive use of the radiant heat of the sun, or indirectly through the conversion of sunlight into electricity (photovoltaics). Solar energy is already used in many water and space heating applications. Photovoltaics have proved useful in large-scale utility networks but more often in small systems in remote or isolated locations where other fuel sources are restricted; this suggests their potential usefulness in developing countries.

Photovoltaic cells have increased in efficiency up to 30% and, according to some sources, if all costs to society were truly accounted for and added to the cost of generation, photovoltaic energy products would be cost-effective for utility-scale power production by the year 2000. We could expect approximate efficiencies of 30%, 25% and 14% respectively for commercially available concentrator photovoltaic cells, crystalline silicon cells and polycrystalline thin film cells.(23)

Wind energy systems are commercially available for some applications (see, for example, the wind farm just east of San Francisco). These systems convert the kinetic energy of the wind to other forms of useful energy, usually electric. However, the future role of such systems as a generally applied energy source is somewhat limited since they require consistent wind and this is available only in specific locations (e.g., Gaspé Peninsula, Arctic regions). For many alternate energy sources, supply is intermittent, so that employing various energy sources forms a more secure basis for continuous energy production.

Canada also possesses one of the world's largest potentials for tidal-electric power, particularly in the Bay of Fundy. Little mention has been made of this potential in recent years, however, despite the search for alternative energy sources that has arisen from increasing concern about the greenhouse effect.

(23) T. Surek, SOL, Issue 71, July/August 1989.

Several other actual and possible energy sources have not been addressed. For example, geothermal power, practical in some locations, has very little potential in Canada, while hydrogen and fusion have not reached practical levels of development. Both could offer a tremendous, clean source of energy, and research and development in these fields should be strongly encouraged. The 1981 Energy Alternatives study, prepared by the House of Commons Special Committee on Alternative Energy and Oil Substitution, provides a comprehensive review of alternative energy sources, technologies and fuels of interest to Canada.

LAND USE MANAGEMENT

A. Deforestation

Because of the unique ability of plants to photosynthesize (which entails the uptake of CO_2), plants which grow for many years, particularly trees, have the potential to act as a sink for CO_2 . As a tree increases in biomass, it accumulates CO_2 in the form of carbon in the wood, which, if allowed to grow, can act as a temporary reservoir for atmospheric CO_2 . If the tree is burnt, however, the stored carbon will be suddenly and nearly completely lost to the atmosphere. If the global release is greater than the uptake, then the forests could act as a source of CO_2 in the short term. In fact, the forests of the world are releasing CO_2 at a rate faster than they are accumulating it. Globally, it is estimated that they are releasing about one-fifth the amount of CO_2 that is produced from the burning of fossil fuels. In view of this, specific questions are often asked: what can we do to stop deforestation and hence stop the addition of CO_2 to the atmosphere by this avenue; could the forests be cultivated to have enough growth that they could act as a temporary sink for CO_2 ; could they offer a little breathing space so that other long-term policies could be put in place?

It is generally recognized that the largest decreases in forested areas are occurring in the tropical countries, with about half of the release of carbon in 1980 from Brazil, Indonesia, Columbia, the Ivory

Coast, Thailand and Laos. It is also generally estimated that 11 million hectares (ha) are lost each year, with only 1.1 million ha being replanted. Recent analysis of remote sensing data suggests that in 1987, 8 million ha was cleared from the Brazilian Amazon alone. Perhaps even more sobering is the realization that in addition to the release of CO₂, biomass burning, related to: deforestation, shifting cultivation, burning agricultural waste, and fuelwood use, contributes roughly 10-25% of the total annual methane emissions, 5-15% of N₂O emissions, 15-30% of NO₂ (commonly associated with automobiles) and 20-35% of the carbon monoxide emissions. These greenhouse gases have been previously discussed.

Analyses have been conducted which examine the amount of land that would have to be reforested in order to reverse the role of forests in the CO₂ budget and have them act as a CO₂ sink. These analyses included parameters such as the growth rates in the different geographic areas of the world, for example, the tropics or the Pacific Northwest of North America, and estimated the approximate cost of cultivating forests, including the procurement of land.

Where a moderate to high growth rate could be achieved, it is estimated that approximately 465 million hectares of new plantations would be needed to sequester the estimated annual surplus of 2.9 million tons of carbon that is produced. This is the equivalent of 15% of the world total of forests that have closed canopies. Including land costs and start-up costs, the minimum total cost of establishing this amount of plantation in temperate zones would be at least U.S. \$372 billion, with a more realistic cost of more than U.S. \$500 billion. In the tropics, the cost of establishing the same amount of plantation would be closer to U.S. \$250 billion.(24)

(24) R.A. Sedjo, "Forests: A Tool to Moderate Global Warming?", Environment, Vol. 31, No. 1, January/February 1989, p. 14-20.

A similar analysis was prepared by Jessup for the Canadian Wildlife Federation in February 1989,⁽²⁵⁾ but with the intention of determining whether reforestation could play a role in "offsetting" Canada's carbon emissions from burning fossil fuels. According to this analysis, in 1981, lands which were "not sufficiently restocked" (NSR) amounted to 21.9 million hectares and were increasing at the rate of 452,000 hectares each year. The lost carbon accrual potential resulting from this backlog of NSR land amounted to 13.8 million tonnes in 1981, and was increasing at the rate of 277,000 tonnes annually. By contrast, the power generation sector in Canada emitted 19 million tonnes of carbon to the atmosphere in 1980 (Acres International Ltd., 1987) (25.4 million tonnes in 1985, according to Environment Canada).

Although these calculations are admittedly crude, they do indicate that it would be possible to use reforestation in Canada to balance some of its CO₂ surplus, perhaps half of that now emitted through power generation. This might only be possible if the growth rate used in the calculations could be maintained for an extended period. Any assistance that reforestation could lend should be viewed as temporary since trees reach a point where growth slows and they can usefully be harvested. However, if the wood was recycled and the stored carbon was not released, then the forests would have the potential to act as a temporary sink of even longer duration than is usually envisaged. Staggered rotations could also help to prolong this stage. But is reforestation an economically feasible approach?

At roughly \$1,500/ha for silviculture (Barron et al., 1986), reforesting 21.9 million hectares (about 10% of Canada's productive forests) would cost about \$32.9 billion (1982 dollars). This does not include research, protection from disease, pests, and forest

(25) P. Jessup, The Role of Canada's Forest in Carbon Storage: Proposal for a National Carbon Tax, Prepared for the Canadian Wildlife Federation, 24 February 1989, 11 p.

fires, or administration in support of silvicultural activity.(26)

In order to have sustainable forestry, it is necessary to ensure that at least one tree is planted for each tree that is felled and that this replacement tree reaches maturity, an ongoing problem that is often overlooked when calculations of allowable cuts are made. In Canada, we still have a backlog of NSR land, despite initiatives such as the \$1 billion federal-provincial Forest Resource Development Agreements (FRDA) program started in 1985. Similar programs, jointly funded by both levels of government (since forestry is under provincial jurisdiction), or funded in part by a carbon tax, could prove beneficial. There are also lands that might be planted with rapidly-growing hybrid poplars or willows that could hence absorb more CO₂ in the short term, and which could be used in biomass production of ethanol if a policy for using this in flexible fuel engines was implemented. The possibility of planting such species on marginal lands and of introducing incentives for this should be investigated. In the United States, the Department of Agriculture's Conservation Reserve Program provides a framework for such an effort.

Many variables tend to complicate this apparently simple issue. For example, as global warming occurs, the forests could be subjected to increased stresses of heat and drought. This could result in increases in dieback (also associated with acid rain), increased insect infestations (the cold winters often restrict the proliferation of some insect pest species), and/or increases in fires (one of the largest reasons for loss of forests in Canada). Scientists at the Atmospheric Environment Service (AES) of Environment Canada have indicated that "natural wildland fires" have been increasing each decade over the last 30 years and that they contribute 13-14% of Canada's CO₂ emissions. The actual causes of the increase in fires are not really known, but may be the result of increased

(26) Ibid.

mechanization, increased access by the public, and perhaps the increase in drought.(27)

Despite the inherent difficulties of using reforestation to help balance CO₂, the EPA Report maintains that reversing deforestation could be a very cost-effective policy response to climate change. It suggests that the costs of absorbed or conserved carbon could be extremely low in comparison to other options, and could offer other benefits such as forest products, watershed protection, non-point pollution reduction, and recreational possibilities. They suggest that the investments required to implement appropriate field trials and research programs would be small by the standards of the energy industry. It is apparent, however, that the largest opportunity for interim respite to the CO₂ buildup by way of manipulating forest cultivation is in the tropical rainforests. This will be addressed in the section on International Policies.

B. Agricultural Practices

Nitrous oxide is released through microbial processes in soils which are enhanced by the use of nitrogenous fertilizers, the extent of release dependent on the particular soil and atmospheric parameters in a given locale. There do not appear to be any concrete suggestions of how this can be reduced, besides the obvious one of reducing our dependency on nitrogenous fertilizers. Excess nitrogen is also associated with problems of lake eutrophication and dieback in trees.

Although all plants absorb CO₂, most agricultural crops do most of their growth in one season, or else, like fruit trees, are relatively slow in the buildup of carbon over the years. They, therefore, have little effect on the net balance of CO₂, since they absorb carbon and release it in a short period of time. We have already discussed how trees can sequester a large quantity of CO₂ annually, and store it for a finite period of time, perhaps 30 to 70 years of rapid growth and CO₂ uptake. Government programs often give incentives to plant agricultural crops

(27) Globe and Mail (Toronto), 26 July 1989.

whether they are needed or not, however, while at times there are incentive programs discouraging planting a particular crop plant. Some of these programs have had the undesirable effect of having marginal lands cultivated, resulting in erosion and the production of greenhouse gases. It might be possible to encourage the planting of trees in suitable types of marginal land and thus reduce the ongoing erosion there and also making an interim sink for CO₂. The U.S. Department of Agriculture's Conservation Reserve Program could provide a general framework for such an effort.

OTHER GREENHOUSE GASES

In addition to strengthening the Montreal Protocol to reduce and preferably eliminate the future production of CFCs, there is a need to remove the "bank" of CFCs and halons now in circulation. It is unlikely that there is any real hope of recapturing the CFCs that will be slowly released from foam products, for example, but there is the opportunity to recapture those being used in cooling systems and those that are stockpiling in junkyards.

Since the price of CFCs at present is extremely low, industry does not have enough economic incentive to recapture and recycle CFCs from their products or those used in industrial processes. This, in conjunction with a lack of appropriate regulations, leads to a "release and replace" mentality. The best technologies are not always used either. For example, the air conditioning systems in cars are not hermetically sealed and thus allow for a great deal of release of CFCs over the operating life of the system. According to the NRDC, automobile losses of CFCs account for 25% of the annual CFC emission in the United States. It is interesting to note that Vermont has banned the use of CFCs in car air conditioners in that state.

Although a large percentage of the global methane released is from sources that we may not be able to control (e.g., enteric fermentation in cattle or production from rice fields), there are fugitive sources

that have some potential for control. And since the greenhouse potential of each molecule of methane is high, control methods that are easily employed should be considered.

The following sources and quantities of methane are for the Canadian situation; the information is from the study produced by the DPA Group⁽²⁸⁾ for the Federal-Provincial Task Force that has been examining the greenhouse effect in Canada. Fugitive emissions from the petroleum industry are substantial, approximately 2 billion cubic metres (m^3) per year, only a small fraction of which is estimated to be recoverable. Coal mines are responsible for somewhat less, 55 million m^3 /yr, but it has been suggested that a substantial reduction of these emissions from both underground and open-pit mines could be achieved economically. There are not any attempts to recover these emissions. Landfills produce methane when degradation of the garbage occurs without the presence of oxygen. It is estimated that 1.6 billion m^3 /yr is released in this manner, although the gas could instead be captured and used as an energy source and thus bring economic benefits to the operator of the landfill.

Although the generation of methane from landfills could easily be controlled in developed countries, methane production from this source in less developed countries is expected to increase present global generation by three to five times that now generated and lost to the atmosphere, unless appropriate policies are implemented. Biomass burning related to deforestation, shifting cultivation, burning agricultural waste, and fuelwood use contributes approximately 10-25% of the total annual methane emissions.⁽²⁹⁾ This, too, indicates the importance of having policies established in less developed countries.

(28) DPA Group (1989).

(29) EPA Report (1989).

INTERNATIONAL POLICIES

Because of deforestation and their growing consumption of energy, developing countries have an impact on global warming that is expected to continue to increase considerably unless these countries change their policies or are influenced to do so by the developed countries. The participation of less developed countries in the struggle to curtail global warming is crucial.

Industrialized nations such as Canada must be aware that some developing countries will resist accepting the fact that the greenhouse effect is a real phenomenon, which could affect them quite severely. All foreign policies should aim at the outset to convince the less developed countries that global warming is real. It should also be borne in mind that the stabilizing policies adopted by the developed countries are also likely to have some effect on the less developed countries. As an incentive to encourage energy efficiency policies, it might be pointed out to developing countries that such policies could be even more important to a country that has a scarcity of capital. Any country, regardless of overall economic status, can avoid spending money on expanding energy systems.

Perhaps the two largest international barriers to achieving global cooperation are the Third World debt and population growth. Many indebted nations have difficulty in placing environment as a priority, particularly when environmental concerns are viewed as additional costs in the short term. Developed countries are now realizing, however, that this attitude resulted in greater costs in the long term; they must first restructure accounting and practices to reflect this realization before expecting developing countries to accept it. Debt will probably need to be reduced, as a condition for their cooperation. Population growth is probably the most fundamental reason for most environmental problems, including global warming. Involving ourselves in other countries' response or lack of response to this problem is one of the most delicate issues we face. An obvious first step towards solving the problem is education.

It is beyond the scope of this paper to detail how foreign policy should be adapted to include the general principles outlined above. Trading debt relief for forest conservation and reforestation, transferring the appropriate technologies to assist developing countries in approaching the warming problem, and the subtle use of diplomacy could all help to raise concern in developing countries. Simple foreign aid programs can be directed to the grass roots side of the problem in some regions of the world where biomass fuel is used in an inefficient and unsustainable manner. For example, at present, thermal efficiency of camp cookstoves is averaging only 10%, but this could easily be increased to over 60% by switching to new stove designs and higher quality fuels. Improved kilns for charcoal production could also be effective in this regard. In Canada, organizations such as the International Development Research Centre (IDRC) and the Canadian International Development Agency (CIDA) are involved in such questions of technology alternatives for developing countries.

The importance of involving developing countries in the global community is perhaps clearly illustrated through world cooperation on CFCs. In the Montreal Protocol, we have succeeded in achieving the first global agreement on the control of atmospheric pollutants. Yet the People's Republic of China is not signatory to the Protocol, and it intends to go into full-scale production of the same CFCs that the Protocol is attempting to restrict. If all goes according to their present plans, China will become the world's largest producer of CFC-11 and CFC-12.⁽³⁰⁾ Similarly, that country has the greatest potential to increase CO₂ emissions through burning its large coal supplies, a source of energy that it is not likely to ignore for environmental reasons alone. Although we cannot dictate internal policies to China, as trading partners and the transferers of technology, our hands are not tied.

Before we can expect to convince the less developed countries of the need to develop appropriate policies, it is important that we set our own house in order. Although Canada produces only 2% of the

(30) New Scientist, Vol. 121, No. 1651, 11 February 1989.

global emissions of greenhouse gases, such a small proportion that this country alone could not have a substantial direct effect on the global problem, we are one of the largest energy users in the world, consuming per capita four tonnes per year, four times the global average or double that of developed countries of western Europe.⁽³¹⁾ This high per capita use affects our credibility, in spite of our arguments that we are constrained by our northern climate and vast geographical area.

GOVERNMENT PROCESSES

There is a vast array of possible federal government approaches and initiatives that could assist in curtailing the greenhouse effect. These could be in the form of legislation, institutional changes, or approaches to policies and programs of departments, both individually and collectively. A committee similar to the Environment Committee of the Cabinet could be struck at a senior bureaucratic level to oversee the policy development in the different departments. Such a committee could also have input from the interested public and non-government organizations. The implementation of such a system could be specific to the greenhouse effect, but should take into account all aspects of the environment in a context of sustainable development. Similar committees within each department could liaison with the interdepartmental committee.

There is a distinct need for communication with the public about the greenhouse effect and particularly about specific actions that they can take which could be highly effective. Models such as that of Health and Welfare's "Participation" could be examined for their applicability to environmental and in particular greenhouse concerns. Perhaps the development of a CO₂ emission reduction index could arouse public involvement in such an endeavour.⁽³²⁾ The application of similar

(31) Environment Canada, "Understanding Climate Change," A Canadian State of the Environment Report, Draft, August 1989, 52 p.

(32) Robinson (1989).

programs or other types of information programs to the commercial and industrial sector still requires more research, but might be useful in influencing these important greenhouse gas sectors. There is a need to market efficiency and in particular "the need for efficiency."

The Environmental Assessment Review Process (EARP) is scheduled to be entrenched in legislation in the next year. This is an opportunity to ensure that all federal policies and programs undergo an EARP prior to any decision about implementation. The EARP could be extended to other than federal projects and to many sectors, for example, energy, transportation, public land management, coastal development, oceans, agricultural support, and water resource management. The mandate of EARP could be more specific than just "environment" and could embrace global climate change specifically. This is important, since the greenhouse effect is exacerbated by the incremental effects of a multitude of federal actions, directly, indirectly and cumulatively.

An example of such an attempt can be found in the United States. The National Environmental Policy Act (NEPA, 1969) requires the preparation of a detailed environmental impact statement to precede all "major federal actions significantly affecting the quality of the human environment." There was an attempt in 1988/89 to have a policy guidance issued that would have directed federal agencies to consider global climate change in the preparation of environmental impact statements, but in January 1989, this was blocked by the Reagan White House.(33)

It is also interesting to note that in the United States the 101st Congress is entertaining two bills dealing with global warming, one from Senator Timothy E. Wirth and the other from Republican Claudine Schneider. Although each has its own emphasis, both bills require increased federal support for energy conservation and alternative energy sources. Even recognizing that the different U.S. and Canadian systems have their own jurisdictional constraints and freedoms, there are areas in this country too where federal legislation could be implemented.

(33) G.T. Prickett and D.A. Wirth, "Environmental Impact Statements and Climate Change," Environment, Vol. 31, No. 2, March 1989, p. 44-45.

Other legislation in the U.S., the Public Utility Regulatory Policies Act (PURPA), "imposes the expected economic results of a simulated free market in generation, on electric utilities... Under PURPA, utilities are required to purchase electricity from small power producers (SPPs) at a rate geared to the utility's actual benefit from the purchase... To the extent that SPPs can generate electricity at a lower cost than the utility's most expensive sources, it can require the utility to purchase its power at the utility's avoided cost."⁽³⁴⁾ In essence, PURPA has enabled the establishment of a mechanism for accurately pricing various electrical generation options. The development of similar legislation, or at least policy, might allow for fairer pricing between utilities in Canada and the small private generators of electricity. This could result in some structural changes in the electricity-generating sector that could increase energy efficiency and lower overall energy intensity. A careful examination of PURPA should also clarify what difficulties, if any, have been encountered as a result of its implementation, and whether benefits for Canada could be accrued by implementing similar legislation, while avoiding the same difficulties.

DISCUSSION

The approach recommended by the Canadian political community is different from that recommended by the scientific and policy community, which has spent considerable time analyzing ways to control the greenhouse effect. Canada's energy ministers have decided against adopting a target or timetable for reducing emissions of carbon dioxide. This decision was based on the report of a Federal-Provincial Task Force that said that, considering the scientific uncertainties, it would be "prudent to continue

(34) Passmore Associates, U.S. Utility Attitudes and Experiences with the Public Utility Regulatory Policies Act (PURPA) and its Potential Relevance in Canada, Prepared for Energy, Mines and Resources, March 1985, 89 p.

to regard the recommendation of the Toronto Conference as an illustrative target rather than as a formally adopted goal.⁽³⁵⁾

The Task Force did indicate in its analysis and projections that it would be possible to save Canadian society \$108 billion, while at the same time reducing carbon dioxide emissions by as much as 160 megatonnes. This amount is half of what is required to meet the 20% target suggested by the Toronto Conference. However, at the same time, the principal analysis conducted by the DPA Group⁽³⁶⁾ for the Task Force found that the 20% reduction would not only be feasible, but could net society a \$99 billion return through energy savings from implementing efficiency and conservation policies. It was stated that: "The Toronto Climate Conference target can be achieved, but only by doing virtually everything that is technically feasible to reduce carbon dioxide emissions."

Other analyses, such as that of the EPA, indicate that implementing policies now, even in the face of scientific uncertainties, would be most effective, and that "delaying the policy response to the greenhouse gas buildup would substantially increase the global commitment to future warming." They maintain that for developed countries to delay policy actions until 2010 and for developing countries to delay until 2025 (assuming a lag between the two is quite reasonable) would result in a 40% increase in warming commitment by the year 2050, compared to the results of implementing policies in 1990. The NRDC describe the problem of waiting and not implementing policies immediately as follows: "If emissions grow an average of 2% a year until reductions begin and we begin a reduction program in 1990, we will have to cut net emissions an average of 2.6% per year during the 1990s to achieve the 20% goal by the year 2000. If we do not begin until 1992, we will have to reduce emissions 3.7% per year for the rest of the decade, or almost 60% faster. If we delay until 1994, we

(35) Globe and Mail (Toronto), 29 August 1989.

(36) DPA Group (1989).

will face the near-impossible task of reducing emissions 5.5% a year for the rest of the decade."⁽³⁷⁾

In addition to the exacerbation of the problems caused by a delay, the implementation of certain policies or inactions will also contribute to the greenhouse effect. According to the EPA, those with the greatest detrimental effect are those that reduce the rate of efficiency improvements (the cuts in research and development in Canada could be considered as an example) and those that reduce the cost of synthetic fuels (such as the Canadian subsidization of tar sand development). It seems quite clear that if we seriously attempt to set an example to the global community, Canadian policies addressing global warming should be implemented soon.

The costs of reducing emissions are likely to increase as the time allowed for these reductions is shortened. In particular, the longer we wait, the more industrial infrastructure will be installed, and it will become increasingly difficult and expensive to replace it. Even the present infrastructure will be difficult to change (although this would be cost-effective in the long term), and according to the EPA, it will take between 20 to 50 years to alter the technological base of industrial societies.

The EPA and policymakers have suggested the need for both long-term and short-term approaches to the problem. In the short term, strategies should rely on pricing and regulation. The price of fossil fuels and other greenhouse gas sources should reflect the full social and environmental costs. The revenues thus raised could finance other relevant projects. Complementary regulatory programs will be needed in many cases, particularly if pricing strategies are ineffective. A variety of regulatory strategies could be employed: performance standards with appropriate enforcement and penalties, emissions offsets (tree planting for example), or marketable permits. There is also a need for provincial and municipal policies and actions, which, in addition to federal initiatives, could be directed to utility regulation, building codes, waste management and

(37) Natural Resources Defense Council (1989).

transportation planning. The participation of the public should also be encouraged.

In the long term, research and development of new and promising alternative technologies should be increased. As in the short term, other policies should complement regulatory and pricing programs. For example, government procurement should be directed towards environmentally-friendly purchases, and government contracts should only be awarded after the company has been assessed for its approach to environmental and greenhouse issues in the specific contract negotiation and in more general terms.

It should be apparent that we must address policies that are extremely far-reaching in both an economic infrastructure sense as well as in a political sense. It will take time to iron out all the interrelated effects of policy changes and to determine how the short-term, long-term and most economically-beneficial and/or cost-effective choices are to be made. There appears to be sufficient evidence, however, that movement towards efficiency and conservation is the first step. It is strongly indicated that this can be more than cost-effective; it can achieve substantial economic benefits for society. According to the DPA Group:(38) "Implementing the measures needed to achieve the Toronto Climate Conference target also saves energy and yields economic benefits to society. Hence, neither excessive cost nor lack of proof that carbon dioxide contributes to climate warming is a valid excuse for inaction."

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